

Mass changes when a reactant or product is a gas

4.3.1.3 · Quantitative chemistry · revision notes

Some reactions in open containers seem to break the law of conservation of mass. The measured mass goes up if a gas from the air reacts, and goes down if a gas is produced and escapes. You need to explain these changes using the balanced equation and the particle model.

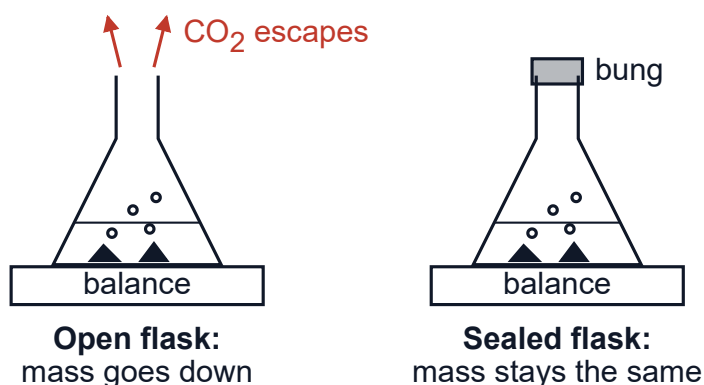
Key facts

- Non-enclosed (open) system: gases can enter or leave, so the measured mass can change
- Gas is a reactant (from the air) → measured mass increases
- Gas is a product (escapes) → measured mass decreases
- Metal + oxygen → metal oxide (mass goes up)
- Metal carbonate → metal oxide + carbon dioxide (mass goes down)
- Mass of gas = change in mass
- Sealed container: mass stays the same

Notes

Why the mass can seem to change

- Mass is always conserved. But in a **non-enclosed system** (an open container) gases can move in or out without being weighed.
- If a **reactant is a gas** from the air (usually oxygen), the measured mass goes **up**.
- If a **product is a gas** (such as carbon dioxide or hydrogen), it escapes and the measured mass goes **down**.
- In a sealed container nothing can get in or out, so the mass stays the same.



Marble chips and acid: in the open flask the gas escapes and the reading falls; with a bung nothing leaves.

Mass increases: metals reacting with oxygen

- $2\text{Mg(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{MgO(s)}$
- Oxygen atoms from the air join onto the magnesium, so the magnesium oxide has a greater mass than the magnesium you started with.
- Mass gained = mass of oxygen that reacted.

Mass decreases: gases given off

- Thermal decomposition of a metal carbonate: $\text{CaCO}_3\text{(s)} \rightarrow \text{CaO(s)} + \text{CO}_2\text{(g)}$. The carbon dioxide escapes into the air, leaving the metal oxide as the only solid product.
- Acid with a carbonate gives off carbon dioxide; acid with a metal such as magnesium gives off hydrogen.
- Mass lost = mass of gas that escaped.

Explaining it with particles

- Gas particles are far apart and move quickly and randomly in all directions, so a gas spreads out and escapes from an open container.
- Oxygen particles in the air collide with the surface of the hot metal and react, becoming part of the solid.

How to answer each type of question

Explain why the mass decreased

2 marks

Grade 4

1. Name the gas produced.
2. Say that it escapes from the open container into the air, so its mass is not measured.

Example. A student added marble chips (calcium carbonate) to hydrochloric acid in an open conical flask on a balance. The mass of the flask and contents decreased during the reaction.
Explain why. [2 marks]

Model answer. Carbon dioxide gas is produced (1). The gas escapes from the flask into the air, so its mass is no longer measured (1).

Explain why the mass increased

2 to 3 marks

Grade 5

1. Say that the substance reacted with oxygen from the air.
2. Name the product (a metal oxide).
3. Say that the mass of the oxygen atoms is added to the solid.

Example. A student heated 1.20 g of copper powder in an open crucible. After heating, the mass of the solid was 1.50 g.
Explain why the mass increased. [3 marks]

Model answer. The copper reacted with oxygen from the air (1) to form copper oxide (1). The oxygen atoms that combined with the copper added to the mass of the solid (1).

Don't lose marks

- ✗ Saying mass is 'lost' or 'destroyed'. Mass is conserved; the gas is just not being weighed.
- ✗ Writing 'a gas is produced' without saying that it **escapes** into the air.
- ✗ Saying a heated metal gains mass because it 'absorbs heat'. Heat has no mass; oxygen atoms are added.
- ✗ Forgetting that the oxygen comes from the air when a question only mentions heating a metal.
- ✗ Subtracting the wrong way round and giving a negative mass of gas.

More tips

Memory tricks

- Gas IN (a reactant from the air) → mass UP.
Gas OUT (a product) → mass DOWN.
- Scan the equation for (g). No (g) at all means the mass stays the same, even in an open container.
- Put a lid on it: in a sealed container the mass never changes.
- The change in mass is the mass of the gas. Nothing else needs working out.

Exam technique

- Use the words 'open' or 'non-enclosed', and name the gas (oxygen, carbon dioxide or hydrogen).
- When an equation is given, point to the gas and its state symbol (g) in your answer.
- A mass-change explanation needs two points: what the gas is, and whether it enters or leaves.
- In practical questions, heating to constant mass shows that the reaction has finished.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State that gases can enter or leave

In an open container, gases can escape into the air or react from the air.

Grade 4

Explain a mass decrease when gas forms

The gas produced escapes into the air, so its mass is no longer measured.

Grade 5

Explain why a heated metal gains mass

Oxygen atoms from the air combine with the metal, so the metal oxide has a greater mass than the metal.

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